(12) UK Patent Application (19) GB (11) 2 345 974 (13) A

(43) Date of A Publication 26.07.2000

(21) Application No 9901119.9

(22) Date of Filing 19.01.1999

(71) Applicant(s)
BG plc
(Incorporated in the United Kingdom)
100 Thames Valley Park Drive, READING, Berkshire, RG6 1PT, United Kingdom

(72) Inventor(s)
Michael Colin Gaskell
Chandra Ratilal Tailor
Graham Finnerty

(74) Agent and/or Address for Service
BG Intellectual Property Ltd
100 Thames Valley Park Drive, READING, RG6 1PT, United Kingdom

(51) INT CL[7]
G01F 25/00

(52) UK CL (Edition R)
G1R RV

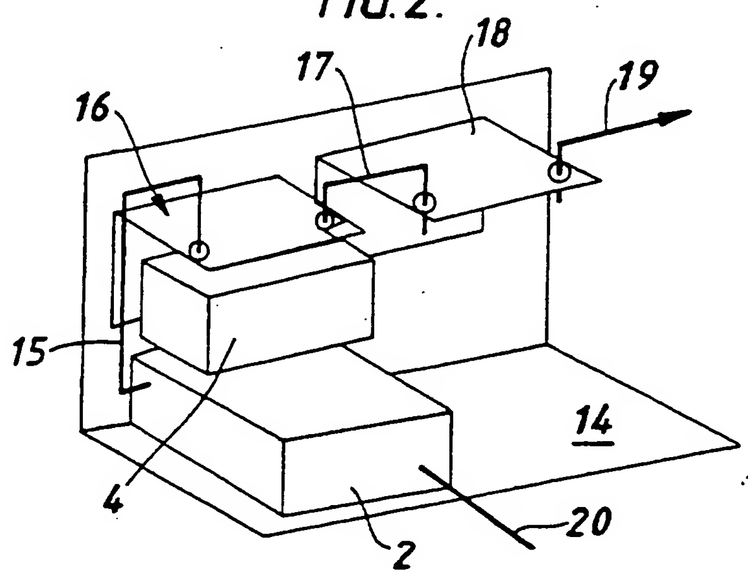
(56) Documents Cited
GB 2283575 A US 4566307 A US 4290298 A

(58) Field of Search
UK CL (Edition Q) G1R RV
INT CL[6] G01F 25/00
ONLINE WPI EPODOC JAPIO

(54) Abstract Title
Testing fluid meters

(57) To test the precision of a fluid meter, apparatus comprises a first fluid meter 4 arranged to be connected in series with the meter to be tested, means 2 to provide a flow of fluid through the meters connected in series, the apparatus being arranged to be used with control means arranged to determine at least one of a volume of fluid passed and flow rate of fluid measured by the first meter and the meter under test. Fluid, e.g gas, flow is via pipework 15 to the test meter 4 and then 17 to the meter to be tested.

FIG. 2.



GB 2 345 974 A

FIG. 1.

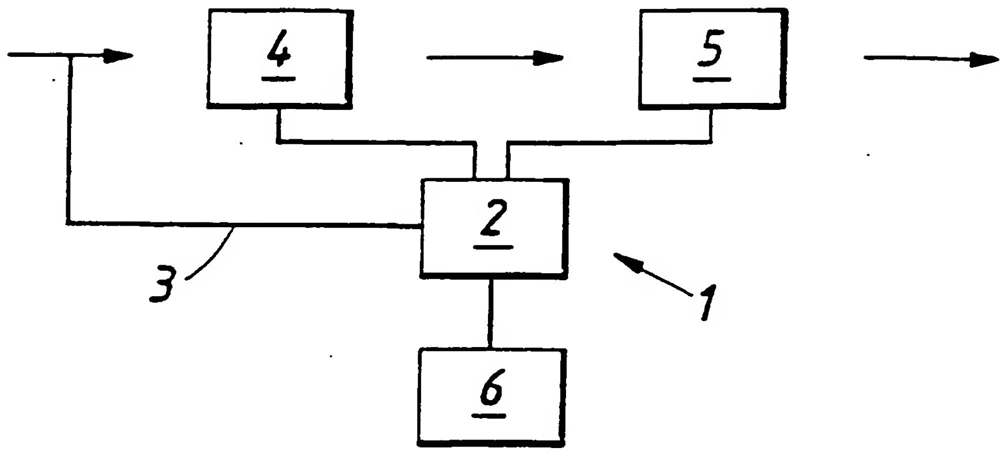
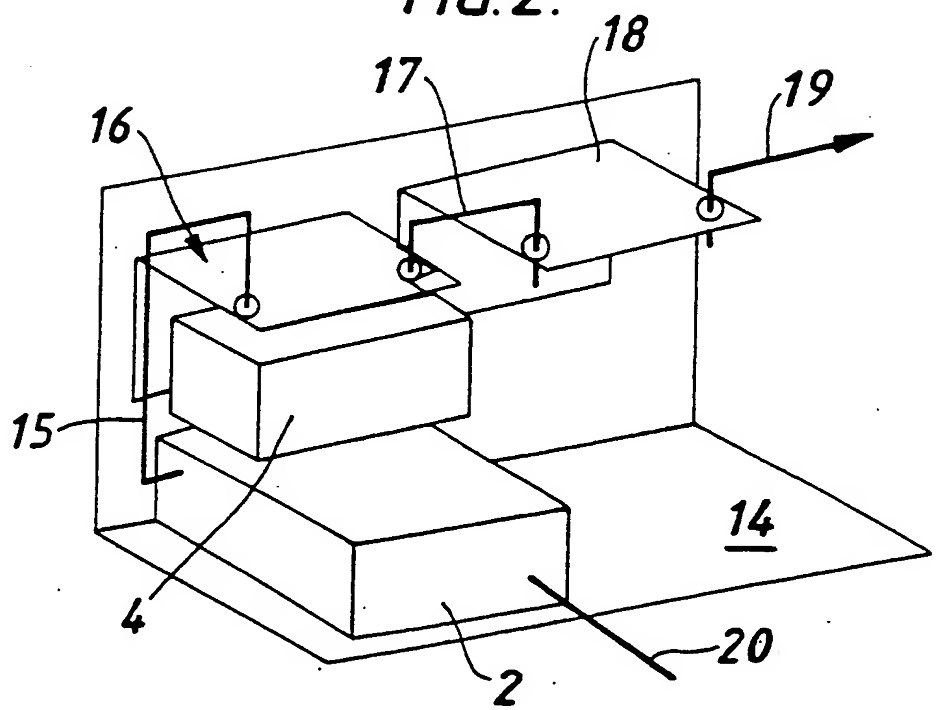


FIG. 2.



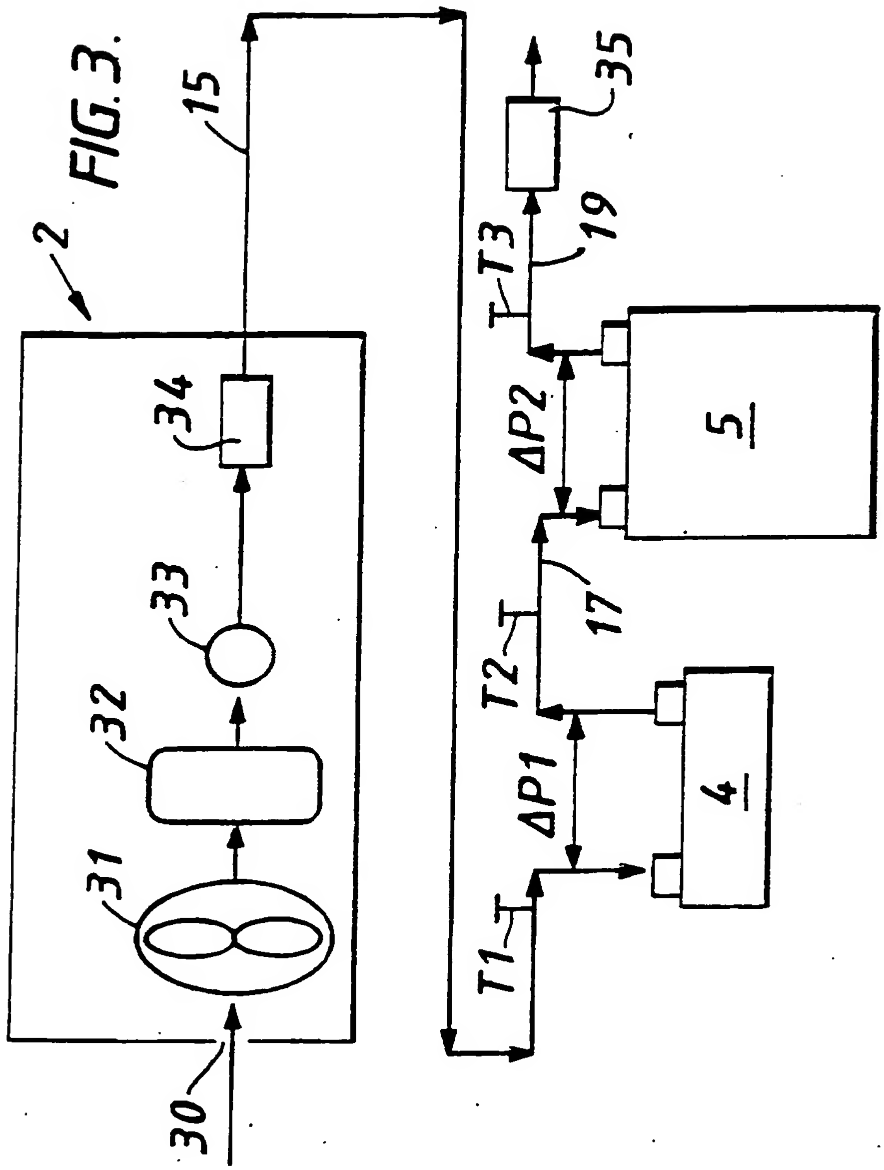


FIG. 3.

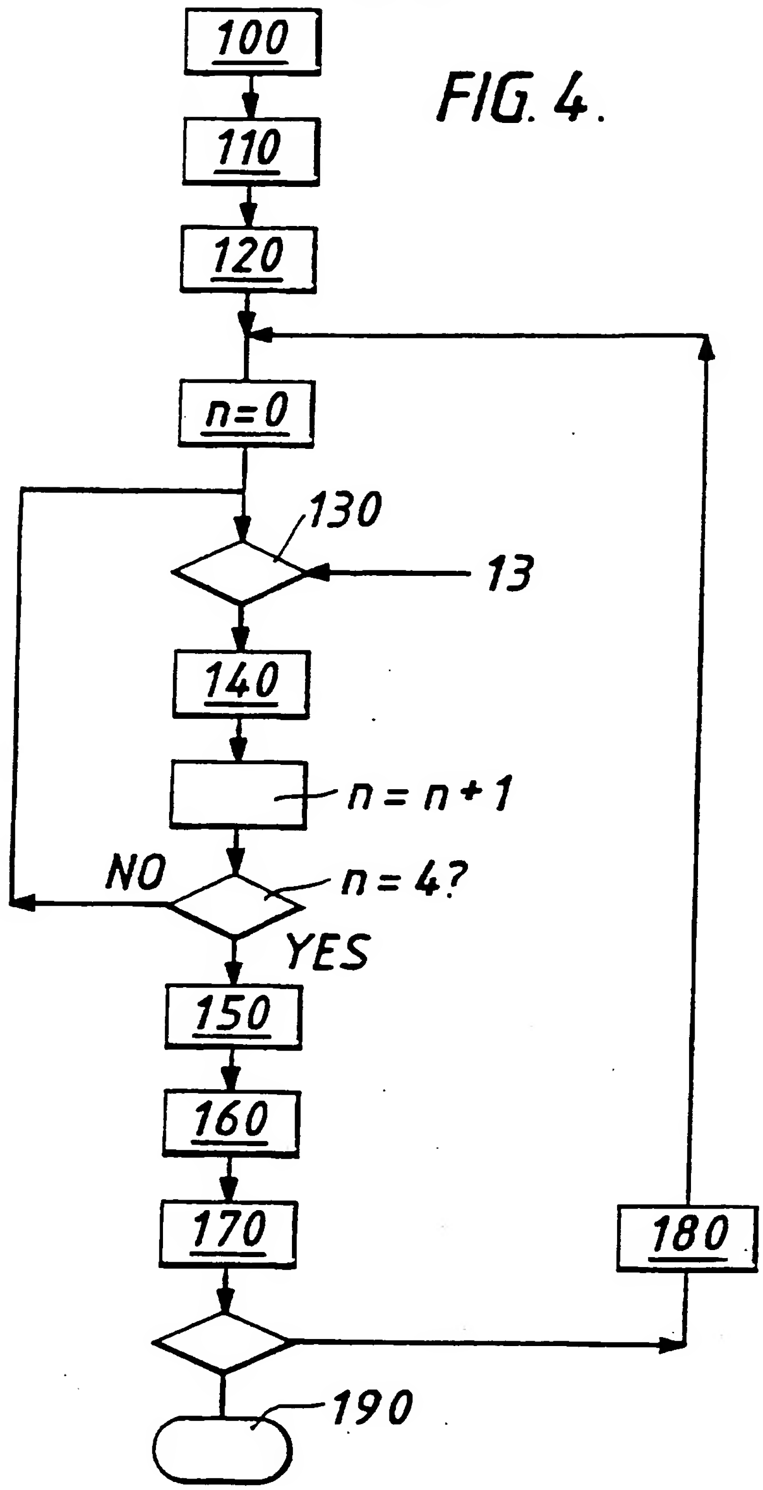


FIG. 4.

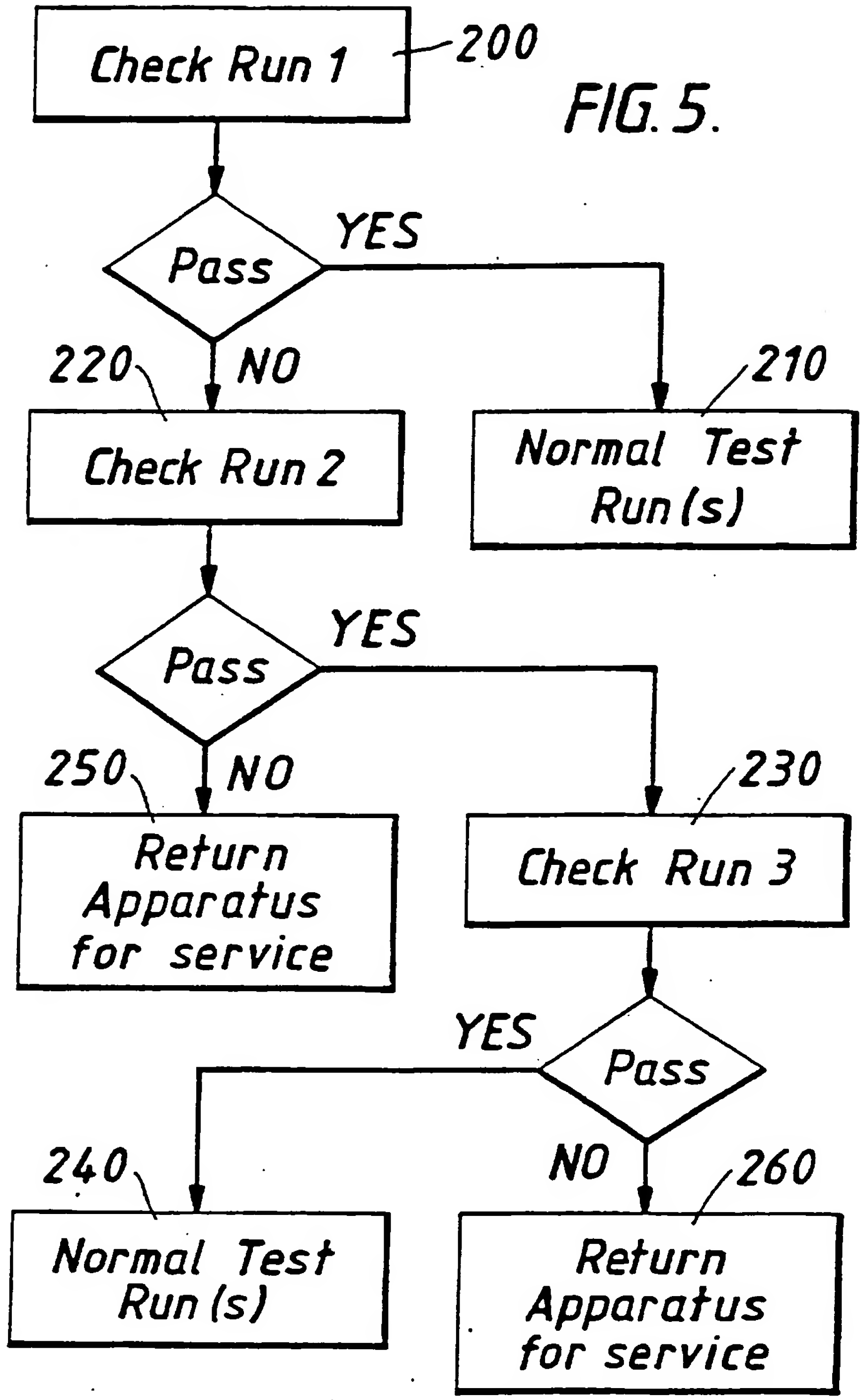

Check Run 1
200
Pass
YES
NO
220
210
Check Run 2
Normal Test Run (s)
Pass
YES
NO
250
230
Return Apparatus for service
Check Run 3
Pass
YES
NO
240
260
Normal Test Run (s)
Return Apparatus for service

FIG. 5.

2345974

METER TESTER

The present invention relates to testing fluid flow or volume meters such as gas meters. Meters should be periodically checked for accuracy to ensure that the consumer is not being overcharged and that the meter provider is not undercharging.

Old, heavily used or suspect meters removed from consumers' premises can be checked for precision on a primary standard which measures fluid flow rates and volumes very precisely. However, primary standards are very expensive, costing many tens of thousands of pounds and require skilled personnel to operate, making their use for checking meter accuracies undesirably expensive. Furthermore primary standards are large, heavy and fragile and so cannot be transported requiring that meters to be tested are shipped to and from the primary standard for testing further increasing costs and introducing considerable delay.

Furthermore different types or sizes of meter to be tested generally require a different primary standard requiring the provision of a multitude of primary standards further increasing costs.

Often, rather than testing a meter, it is simply sent away for refurbishment since the additional cost of refurbishing all old, heavily used or suspect meters rather than just imprecise ones is less than that of testing the meters.

According to the present invention there is provided an apparatus to test the precision of a fluid meter, the apparatus comprising a first fluid meter arranged to be connected in series with a fluid meter to be tested; means to provide a flow of fluid through the first meter and a meter to be tested when in use and connected in series with the first meter and control means arranged to determine at least one of the volume and flow rate of fluid flowing through the meters measured by the first meter and a meter under test.

The control means preferably determines the difference between the volume or flow rate measured by the first fluid meter and the meter under test and if this difference is less than a particular amount provides a signal indicating that the meter under test is satisfactory and if this difference is greater than the particular amount provides a signal indicating that the meter under test is not satisfactory.

Such a test apparatus which does not require a primary standard is inexpensive and compact enabling it to be transported to a consumer's premises where meter testing can be performed, saving shipping costs and time.

The test apparatus is preferably calibrated against a primary standard to ensure precise results.

The first fluid meter is preferably calibrated against a primary standard by first calibrating a meter of the type to be tested against a primary standard to obtain a first calibration factor; calibrating the same meter of the type to be tested against the first fluid meter of the test apparatus to obtain a second calibration factor and calibrating the test apparatus using the first and second calibration factors. Calibrating the test apparatus in this manner ensures that errors produced by the series connection of the first fluid meter of the test apparatus and a meter of the type to be tested are reduced or eliminated. Such errors may arise for example, from the particular flow pattern produced by the series connection of the first fluid meter of the test apparatus and the meter of the type to be tested. Even small errors of this nature are highly significant when the meter testing rejects meters under test which deviate from a reference meter by one percent or less.

The test apparatus preferably uses a plurality of calibration factors, each corresponding to a particular type of meter to be tested to enable precise testing of a plurality of types of meters. Different sizes of similar meters may be considered to be different types of meters for the purpose of this invention.

An example demonstrating the present invention is described with reference to the accompanying drawings in which:

Figure 1 diagrammatically shows a test apparatus;

Figure 2 is a perspective view of the structure of a test apparatus;

Figure 3 shows the flow paths within the test apparatus;

Figure 4 shows the sequence of operations performed by the test apparatus during the testing of a meter and

Figure 5 shows a sequence of check runs for determining whether a test apparatus is suitable to be kept in use or should be returned for servicing.

Figure 1 diagrammatically shows a test apparatus 1 comprising a control means 2 able to control via a control line 3 the rate of flow of a fluid to a reference meter 4. The reference meter 4 is arranged to measure the volume of fluid passing therethrough and supply the fluid to a meter under test 5 connected in series with it, which also measures a volume passing therethrough. The control means 2 , possibly under the control of a computer 6, is arranged to take readings of a volume of fluid passed through the reference meter 4 and a meter under test 5 at particular intervals which, in the present example, are triggered by a particular volume of fluid having been measured by one of the meters 4, 5.

Figure 2 shows a perspective view of a test apparatus 1. This apparatus is arranged to test a gas flow meter but could equally be used with other flow meters such as water meters, petrol pumps, etc.

The control means 2 is mounted on a support 14 and connected to a conduit 15 connected between the control means 2 and a gas input port of the reference meter 4. The reference meter 4 is securely mounted on the support 14 by a bracket 16. One end of a second conduit 17 is connected to an output port of the reference meter 4 and the other end of the second conduit 17 is supported by a bracket 18 such that it may be connected to the gas input port of a meter to be tested (not

shown) when in use. An exhaust conduit 19 arranged to be connected to the outlet of a meter to be tested (not shown) when in use is also supported by the bracket 18. The control means 2 may include a processing means such as a computer or may be connected to a processing means such as a computer 6 by a communication link 20.

Figure 3 shows the flow paths of the apparatus. Inside the control means 2 there is provided means 31 for generating a flow of gas, in this case a fan or compressor which draws in air from an inlet 30 when in use. The fan is preferably able to operate at a number of predetermined speeds to supply a corresponding number of gas flow rates. The flow of air is in this example then passed through means 32 to reduce or eliminate any pulsation produced by the flow generating means 31. This pulsation reduction means 32 may be a ballast vessel or expansion chamber. The flow of air is in this example then passed through a pressure regulator 33. To provide a convenient approximate indication of the amount of air passing through the apparatus a rotameter 34 is provided in the flow path. However, each of the pulsation reduction means 32, the pressure regulator 33 and the rotameter 34 is not essential and any or all of them may be omitted.

One or more temperature sensors may optionally be provided to compensate volume readings for variations in the temperature of the gas to be measured. In this example, the conduit 15 connecting the control means 2 to the reference meter 4 may be provided with a temperature sensor T1, the conduit 17 connecting the reference meter 4 to the meter under test 5 may be provided with a temperature sensor T2 and the exhaust conduit 19 from the meter under test may be provided with a temperature sensor T3. A further temperature sensor T4 (not shown) may be provided to measure the average air temperature surrounding the apparatus during a test run. One or more pressure sensors Δ P1, ΔP2 may be provided to measure the differential pressure across each meter in order to compensate readings for variations in pressures. However, like the temperature sensors, the differential pressure sensors are not essential.

To calibrate the test apparatus 1, one or more (preferably four) gas flow meters of the type which are to be tested in the field and termed transfer meters are calibrated against a highly accurate primary standard by determining the difference in readings between a transfer meter and the primary standard for the same gas flow. A calibration factor against the primary standard is found for each transfer meter. A calibration factor may be found at each of a number of different flow rates (e.g. 0.24m^3/hour, 1.2m^3/hour and 6.0m^3/hour) produced by the flow generating means 31 to form a calibration curve for each transfer meter for even more precise calibration.

The same transfer meters are then run on the test apparatus 1 as the meter under test 5 in a similar fashion and a second calibration factor or curve corresponding to a difference in readings between each transfer meter and the reference meter 4 is determined. The difference between the two calibration factors or curves is the correction factor required for that particular test apparatus 1 when used with a meter to be tested of the type and size of the transfer meter.

This two stage method of calibration is more precise than simply calibrating the reference meter 4 against a primary standard. This two stage calibration method takes account of variations that would be produced due to the particular flow pattern within the particular type of gas flow meter to be tested when connected in series with the reference flow meter 4. These flow patterns would otherwise cause variations in the volume of gas measured which could be significant in the present case in which a small percentage difference between the meter under test 5 and the reference meter 4 leads to that meter being sent for refurbishment.

For more precise calibration the two-stage calibration exercise may be performed using more than one transfer meter and an average found for the plurality of meters. If used at more than one flow rate, the transfer meter may be calibrated by running at each of the flow rates a plurality of times. The first stage of calibration could then be performed with a number of transfer meters and the transfer meters that produce the most consistent results used for the two-stage calibration. After the two-stage calibration factor or curve has been determined, the test apparatus 1 may be

checked against the primary standard with one or more transfer meters to ensure that it is precise. This two stage calibration may be performed periodically, e.g. annually, to ensure that the test apparatus calibration factor has not drifted.

Calibration factors or curves may be determined for each type of gas flow meter that may be tested (for example bellows meters of various sizes, token meters of various sizes, ultrasonic meters of various sizes, etc.) and if necessary also for other fluid meters such as water meters.

The operation of the test apparatus is illustrated in Figure 4. First the size and type of meter to be tested is determined by reference to the meter itself. This information is then entered into the control means 2 (Step 100) of the test apparatus 1, either directly if the control means includes a processing means or via communication link 20 from an associated processing means e.g. a computer. The control means 2 or computer then accesses an appropriate calibration factor or curve (Step 110) previously determined for the size and/or type of meter to be tested when connected in series with the reference meter 4 in the test apparatus 1. The calibration factor or curve may be selected from a look-up table.

The meter to be tested is then installed in position in the test apparatus so that it is connected in series with the reference meter 4. The control means 2 then activates the air flow generating means 31 (Step 120) which is preferably a fan able to operate from a 12V power supply which is readily available in a van for example. Control means 2 has a number of available flow settings, but in the present example operates the fan 31 to produce flow rates of 1.2m^3/hour or 6.0 m^3/hour.

The control means 2 monitors the passage of air through the meter under test 5 via either a standard optical pick-up device applied to meters with a non-electrical output signal e.g. meters which have one or more dials to show gas consumption, or a suitable pulse from meters which do have an electrical or optical output corresponding to the flow/volume of gas passing therethrough. This gives an

indication each time that the meter under test 5 has passed one cubic unit of gas. This may be for example a cubic foot or 10 litres of air.

Each time that the meter under test 5 indicates that one cubic unit of air has passed with a pulse (Step 130), the control means 2 reads the volume registered by the reference meter 4 (Step 140). The reference meter 4 is used as a consistent measure of volume passed through the test apparatus 1. The control means 2 determines the volume indicated by the reference meter 4 at the start of the first pulse from the meter under test and at each subsequent pulse, in this particular case for a total of four pulses to measure the total volume passed during the passage of each cubic unit of air registered by the meter under test 5. The total number of pulses can be set to any appropriate value.

After a pre-determined number of cubic units are indicated as having passed through the meter under test 5 (set at 4 cubic feet in this example), the test is complete and the control means 2 determines the volume registered by the reference meter 4 and the difference in volume passed between the meter under test 5 and the reference meter 4 (Step 150).

The control means 2 determines whether the meter under test 5 is within acceptable measurement limits (Step 160) by comparing the difference in volume measured between the two meters with a predetermined value and displays a message to the engineer that the meter has passed the test if the difference is less than this value or failed the test if the difference is greater than this predetermined value (Step 170). The control means 2 may then determine whether the test is to be performed at a further flow rate. If it is, it sets the flow generating means 31 to the appropriate flow rate (step 180) and goes to step 120. If no further flow rates are to be measured the control means stops (step 190).

The test apparatus 1 has been found to have an accuracy of better than 1%. Hence for meters which have a legal metrological limit of +/- 2%, the test apparatus 1 may reject meters whose accuracy is assessed at +1% to +2% and -2% to -1%.

The control means 2 may allow data about the meter under test 5 to be entered into the control means 2 or computer if appropriate using a data entry screen. This may record data about the meter (unique serial number, manufacturer, year of manufacture, diaphragm code, removal address, etc.)

The control means 2 may include a telephone Modem connection to allow data to be up-loaded to a computer at a central station for analysis.

The control means 2 may take readings from one or more of the temperature sensors T1-T4 during the test to compensate for variations in the volume of the gas due to ambient temperature. For example during particularly cold conditions eg. in Winter, a meter which may otherwise just pass the test may, in these circumstances, be failed.

The control means 2 or Computer may take readings from one or more differential pressure sensors $\Delta P1$, $\Delta P2$ during the test to compensate for variations in the volume of a fluid or air due to a pressure drop across each meter. .

The test apparatus site (vehicle or depot) could have one check meter of each type which is to be tested in the field which is used on each day that meter testing is to be performed. The check meter may be tested on the test apparatus to ensure that the apparatus 1 is giving results with sufficient accuracy (e.g. within +/- 0.25%). Each check meter should be periodically tested with the same primary standard.

A 'check meter' routine to ensure that the test apparatus is providing precise results may be used which performs a check run using a check meter and then on the basis of the result proceeds as follows and as shown in Figure 5: Check Run 1 (box 200); if the meter passes the acceptance criteria then proceed with normal testing (box 210); if the first check fails then undertake a second check run (box 220). Check Run 2: If the second check run passes the acceptance criteria then undertake a third check run (box 230); Check Run 3: if the third check run passes the acceptance

criteria then proceed with normal testing (box 240). If the second check run fails the acceptance criteria (box 250) or the third check run fails the acceptance criteria (box 260) then the test apparatus 1 should not be used for testing - it should be returned to the depot (or wherever) for service. It may be prudent to first check the test apparatus 1 with a second check meter at the depot (or test the check meter on another test apparatus 1) to identify which is working correctly.

The invention should not be considered to be restricted to the features in the test apparatus described in the example above. For example the test apparatus need not take measurements at every unit volume of gas that passes through the meter under test, but could take a reading only when a particular volume has passed or after a particular period of time. Furthermore, either the reference meter or the meter under test could be used to signify to the control means that a particular volume has passed.

CLAIMS

1. An apparatus to test the precision of a fluid meter, the apparatus comprising a first fluid meter arranged to be connected in series with a fluid meter to be tested; means to provide a flow of fluid through the first meter and a meter to be tested when in use and connected in series with the first meter and the apparatus being arranged to be used with control means arranged to determine at least one of a volume of fluid passed and flow rate of fluid measured by the first meter and a meter under test.

2. An apparatus according to claim 1, wherein the control means is arranged to determine the difference between the volume or flow rate measured by the first fluid meter and a meter under test and if this difference is less than a particular amount the control means is arranged to provide a signal indicating that the meter under test is satisfactory and if this difference is greater than the particular amount provide a signal indicating that the meter under test is not satisfactory.

3. An apparatus according to claim 1 or claim 2, wherein the control means is arranged to determine the volume or flow rate measured by the first fluid meter as a function of a test apparatus calibration factor corresponding to the type of meter to be tested.

4. An apparatus according to claim 3, wherein the test apparatus calibration factor is determined by first calibrating a meter of the type to be tested

against a primary standard to obtain a first calibration factor; calibrating the same meter of the type to be tested against the first fluid meter of the test apparatus to obtain a second calibration factor and determining the test apparatus calibration factor as a function of the first and second calibration factors.

5. An apparatus according to claim 4, wherein the difference between the first and second calibration factors is used as the test apparatus calibration factor.

6. An apparatus according to any of claims 3 to 5, wherein the control means uses a test apparatus calibration factor selected from a plurality of factors dependent upon the type of meter to be tested.

7. An apparatus according to any of claims 3 to 6, wherein the control means has a memory and the one or more calibration factors are stored in the memory.

8. An apparatus according to any of claims 3 to 7 wherein the means to provide a flow of fluid is arranged to provide fluid at more than one flow rate and the control means is arranged to determine at least one of the volume and flow rate of fluid flowing through the meters measured by the first meter and a meter under test at each of the flow rates.

9. An apparatus according to claim 8, wherein a separate test apparatus calibration factor is used for each flow rate.

10. An apparatus according to any of claims 3 to 9, wherein the apparatus includes one or more temperature sensors and the one or more test apparatus calibration factors are dependent upon the temperature measured by the one or more temperature sensors.

11. An apparatus according to any of claims 3 to 10, wherein the apparatus includes one or more pressure sensors and the one or more test apparatus calibration factors are dependant upon differential pressures measured across each meter by the one or more pressure sensors.

12. An apparatus according to any of the preceding claims, including means to convert a volume/flow signal from a mechanically rotating dial of a fluid meter to an electrical signal to be received by the control means and the converting means is arranged to be applied to a mechanically rotating dial of a fluid meter to be tested.

13. A test apparatus substantially as hereinbefore described with reference to the accompanying drawings.

The Patent Office

INVESTOR IN PEOPLE

13

Application No: GB 9901119.9 **Examiner:** Roger Binding
Claims searched: 1-13 **Date of search:** 22 July 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): G1R (RV)

Int Cl (Ed.6): G01F 25/00

Other: Online WPI EPODOC JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	GB 2283575 A (NORTHEDGE)	1
X	US 4566307 A (BOYKIN)	1
X	US 4290298 A (SEVERSON)	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		